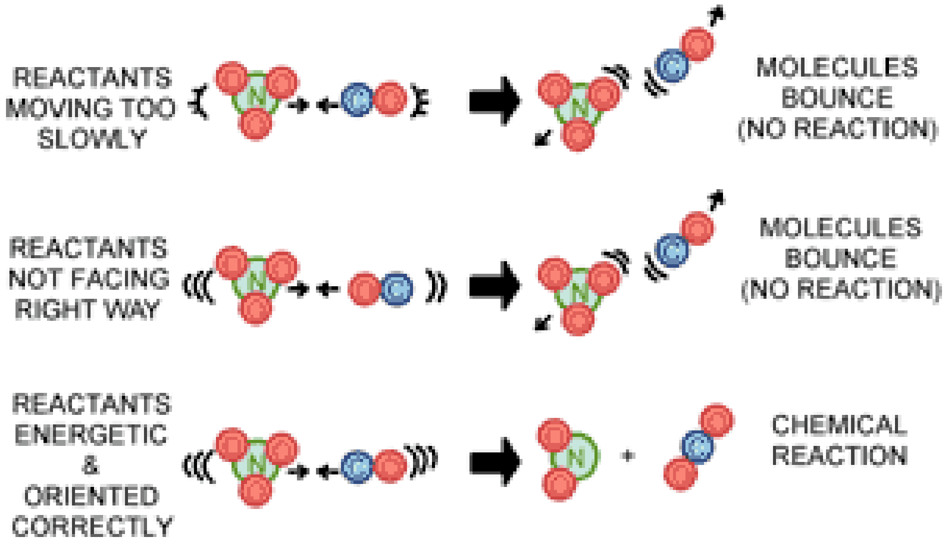
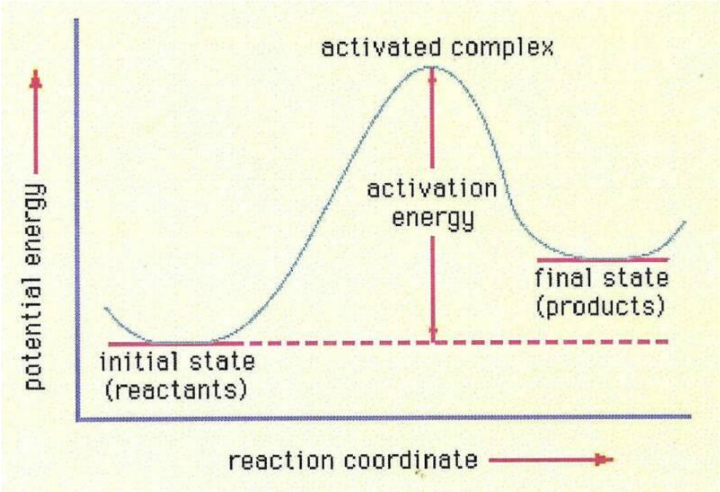
Activation Energy & Catalysts

Collision Theory

- Accounts for observed characteristics of reaction rates
- For a reaction to occur:
  - Correct orientation of molecules
  - Sufficient energy



Activation Energy



- Potential energy diagram
- Activated complex located at top of hill or barrier
  - Passing over barrier changes reactants into products
- Activation energy—amount of energy required to form activated complex
  - Exothermic versus endothermic

Activation Energy

- Can be calculated from the Arrhenius Equation:

$$k = Ae^{\frac{-E_a}{RT}}$$

  - A = frequency factor
  - R = gas constant(8.3145 J/K·mol)
  - E_a = activation energy
  - k = rate constant
  - T = temperature (K)

Determining Activation Energy

- Multiple temperatures

$$\ln(k) = -\frac{E_a}{R}\left(\frac{1}{T}\right) + \ln(A)$$

  - Plot ln k versus 1/T
  - Slope of this line = $-E_a/R$
- Only two temperatures

$$\ln\left(\frac{k_2}{k_1}\right) = \frac{E_a}{R}\left(\frac{1}{T_1} - \frac{1}{T_2}\right)$$

Activation Energy Example

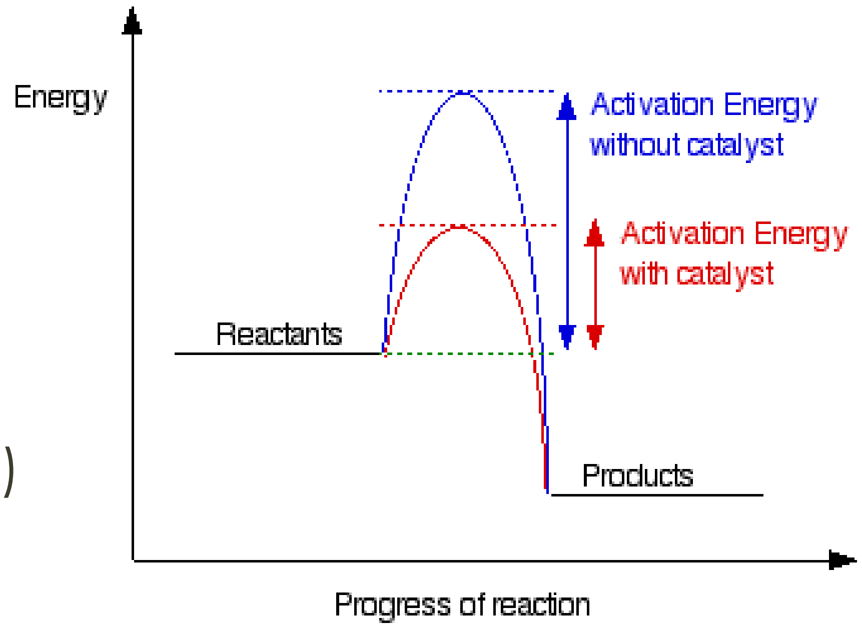
- A first order reaction has constants of 4.6 x 10^{-2} s^{-1} and 8.1 x 10^{-2} s^{-1} at 0°C and 20°C, respectively. Calculate the value of activation energy.

$$\ln\left(\frac{0.081}{0.046}\right) = \frac{E_a}{8.3145\,\frac{J}{mol \cdot K}}\left(\frac{1}{273\,K} - \frac{1}{293\,K}\right)$$

$$0.57 = \frac{E_a}{8.3145}\left(2.5\ x\ 10^{-4}\right) \rightarrow E_a = 19000\,\frac{J}{mol}$$

Catalysts

- A substance that speeds up a reaction without being consumed
  - Different from an intermediate (substance formed in one step and consumed in the next)
  - Lowers the activation energy



Types of Catalysts

- Homogeneous catalyst—one that is present in the same phase as the reacting molecules
- Heterogeneous catalyst—exists in a different phase
- Enzyme → biological catalysts